REMARKS

Review and reconsideration on the merits are requested.

Formalities

Applicant appreciates the Examiner accepting the drawings and acknowledging receipt of certified copies of the priority documents (there are two priority documents).

The Prior Art

U.S. Patent Publication No. 2003/0134493 Cho et al (Cho); U.S. Patent Publication No. 2002/0046693 Kiyoku et al (Kiyoku).

The Rejections

Claims 1, 10, 13, 22, 23, 47, 53 and 54 under 35 U.S.C. § 102(e) as anticipated by Cho. Paragraph 2 of the Action.

Claims 1, 2, 10, 13, 17-24 and 46-55 under 35 U.S.C. § 102(b) as being anticipated by Kiyoku.

The Examiner's position on the prior art is set forth in the Action and will not be repeated here except as necessary to an understanding of Applicants' traversal which is now presented.

In summary, in **Response to Arguments**, the Examiner has, as later explained, predicated the argument on a factually flawed conclusion regarding the fact that when some non-intentional incorporation of dopant materials will occur in Cho, such doping levels would be expected to be well below the carrier concentration of around $1 \times 10^{17}/cm^3$. Applicant submits a rebutting publication.

With respect to the rejection over Kiyoku, Applicant later traverses in detail.

Claim 1 of the Present Application

1. A self-supported III-V nitride semiconductor substrate having a substantially uniform carrier concentration distribution at least on its outermost surface, wherein said substrate

has a carrier concentration of 1 x 10^{17} cm^{-3} or more, and wherein variations in the carrier concentration are within ±25% in said outermost surface, said variations in the carrier concentration lying in a surface (in-plane) thereof.

Distinguishing Features of the Claimed Invention

Distinguishing features of the claimed invention are: the self-supported III-V nitride semiconductor substrate has a substantially uniform carrier concentration distribution at least on its outermost surface, where the substrate has a carrier concentration of 1 x 10^{17} cm^{-3} or more and variations in the carrier concentration are within ± 25% in the outermost surface, the variations in the carrier concentration lying in a surface (in-plane) thereof.

In contrast, Cho teaches a method for doping gallium nitride (GaN) substrates where gallium (Ga) is transmuted to germanium (Ge) by applying thermal neutron irradiation to a GaN substrate material or wafer, where the Ge is introduced as an impurity in GaN and acts as a donor. The concentration of Ge introduced is controlled by the thermal neutron flux such that when the thermal neutron irradiation is applied to a GaN wafer the fast neutrons are transmuted together with the former and result in defects such as collapse of crystallization. The GaN wafer is thermally treated or processed at a fixed temperature to eliminate such defects (see paragraph [0011] of Cho).

In Cho, the neutrons do not possess an electrical charge. This neutron transmutation doping (NTD) of the GaN substrates allows for rather **extreme uniformity** of doping of impurities **regardless of material thickness.** This is because, as compared with other doping methods, NTD has the advantage that, **provided** the isotopes of Ga and N are uniformly distributed, the neutrons are uniformly captured, and, therefore, the transmuted impurities are

distributed uniformly in the samples. Another advantage is that the concentration of impurities is precisely controlled by controlling the neutron dosages (see paragraph [0025] and Fig. 1 of Cho).

Cho does not teach or suggest the present invention and is silent as to a uniform surface carrier concentration distribution not only in anywhere in the substrate, that is, in a direction perpendicular to a substrate surface or in a surface (in-plane), but also as to the degree of the uniformity regarding a numerical range as recited in claim 1, that is, when the substrate has a carrier concentration of 1×10^{17} cm^{-3} or more, variations in the carrier concentration lying in a surface (in-plane) are preferably within ± 25%.

It is also quite clear that if a carrier concentration in a substrate surface (in-plane) of the undoped GaN substrate before neutron transmutation doping in Cho is nonuniform, it would be impossible to obtain a self-supported III-V nitride semiconductor substrate as disclosed and claimed in the present application, even if one attempted to carry out precise control of uniform doping by the Cho thermal neutron transmutation method.

Since Cho is fortuitous prior art, i.e., Cho has no appreciation of the present invention, rather, simply happens to deal with NTD which does not result in a teaching of the present invention to one of ordinary skill in the art, the Examiner has urged in the Action at page 5 as follows.

Specifically, the Examiner states in **Response to Arguments** at page 5, lines 4-10, as follows:

> "[I]t is apparent that the method in Cho must result in uniformity within the claimed ranges. Additionally, since the GaN is not intentionally doped prior to the neutron transmission doping, but rather the doping results from transmuting the Ga in the GaN lattice into Ge, it is readily understood by a person skilled in the art that while some non-intentional incorporation of dopant materials will occur, such doping levels are expected to be well below the

> carrier concentration of around 1 x $10^{17}/cm^3$, and thus should not significantly affect the uniformity of the carrier concentrations."

Applicant submits that the following remarks regarding Cho are not factually correct.

> "[I]t is readily understood by a person skilled in the art that **while some non-intentional incorporation of dopant materials will occur, such doping levels are expected to be well below the carrier concentration of around 1 x $10^{17}/cm^3$**, and thus should not significantly affect the uniformity of the carrier concentrations." (bolding added)

However, the above statement is technically and factual flawed as non-intentional incorporation of dopant materials actually occurs in a carrier concentration in a range of 2 x 10^{17} m^{-3} and 1 x 10^{19} cm^{-3}. Supporting the above position, Applicant submits the following publication.

> GROWTH AND EVALUATION OF GAN THICK FILMS
> by Y. Kim, J. Kruger, H. Feick, and E. R. Weber,
> Department of Material Science and Mineral Engineering,
> University of California at Berkeley, Berkeley, California 94720
> Appeared in
> Final Repoert 1998-1999 for MICRO Project 98-168
> Industrial Sponsor: American X-tal Technology (AXT).
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> Note: [6]; W. Gotz et al. "Electronic and structural properties of GaN grown by hydride vapor phase epitaxy," Appl. Phys. Lett., 69, (1996) 242.

Kim et al teach:

> [I]t is noted that HBPE GaN films are commonly **unintentionally** n-type doped and exhibit free carrier concentrations in the range between 2 x $10^{17}cm^{-3}$ and 1 x 10^{19} cm^{-3}[6]. (bolding added)

Accordingly, one of ordinary skill in the art interpreting the teaching of Cho, which is silent as to a uniform service carrier concentration distribution in a direction perpendicular to a substrate surface or in a surface (in-plane) but also silent as to the degree of uniformity regarding

the specific range of claim 1 would not reach the present invention and, accordingly, claim 1 of the present application is not anticipated by Cho.

With respect to claims 2, 13, 22 and 23, Applicants rely on their arguments regarding claim 1.

Claim 10

10. A III-V nitride semiconductor substrate having a substantially uniform carrier concentration distribution at least on its outermost surface, wherein said substrate has a carrier concentration of less than 1×10^{17} cm^{-3}, and wherein variations in the carrier concentration are within ± 100% in said outermost surface, said variations in the carrier concentration lying in a surface (in-plane) thereof.

Since one major distinguishable feature of claim 10 lies in the variations of the carrier concentration lying in a surface (in-plane) thereof, quite clearly Cho does not suggest claim 10.

With respect to claims 47, 53 and 54, Applicants rely on their arguments regarding claim 10.

Withdrawal is requested.

Rejection Over Kiyoku

Applicant here focuses on the crystal growth of a nitride semiconductor. They again refer to **Response** at page 5, line 17 to page 6, line 3, where the Examiner states:

> "Kiyoku does disclose a step of performing lateral overgrowth over a selective growth mask layer, wherein the laterally overgrown portions merge to form a flat interface having substantially few defects (see paragraphs 0038-0039, 0059, 0067; figure lc). After layer 16 is made flat, wherein layer 17 has very few crystal defects, and thus high uniformity (see in particular, paragraphs 0039 and 0067). Alternatively, since layers 16 and 17 are continuously grown, at some point, the surface must be considered "flattened," such that the upper portion of layer 16 in

addition to layer 17 are considered the substantially uniform layer."

The Examiner's attention is, however, directed to FIG. 5A of Kiyoku. A careful review of FIG. 5A shows that there are crystal defects which are sparsely or not densely present on the surface of layer 16. This is a consequence of the Kiyoku process. Specifically, in Kiyoku, a portion of the defects generated on the layer 12 between the adjacent masks 13 is grown only in a perpendicular direction to reach the surface of the layer 16. These features of the crystal growth of Kiyoku result in nonuniformity in the carrier concentration in a surface (in plane) of the substrate, even though layer 17 is grown thereon.

In contrast to Kiyoku, per the present invention the formation of facet planes is caused to appear in crystal growth interfaces in the initial stage of growing a III-V nitride semiconductor substrate, followed by performing crystal growth while forming a plurality of projections on a crystal growth interface. Thereafter, one conducts crystal growth until recesses between the projections are buried, so that the crystal growth interface becomes flat, making it possible to **reduce** the nonuniformity in the carrier concentration in a surface (in plane) of the substrate (see page 7, lines 12-18; and page 10, lines 15-21, of the specification.

Therefore, a person skilled in the art referring to Kiyoku, which merely teaches a decrease in the crystal defects and is silent as to the reduction of the nonuniformity in the carrier concentration in a surface (in plane) of the substrate, would not easily reach the invention of claim 1, and, accordingly, claim 1 of the present application is not anticipated by Kiyoku.

The Examiner's attention is specifically directed to the fact that claim 1 calls for "variations in the carrier concentration are within ±25% in said outermost surface, said variations in the carrier concentration lying in a surface (in-plane) thereof."

Kiyoku contains no suggestion of such limitation, and as the Examiner has advanced no reasonable basis for a conclusion of inherency, for this additional reason, claim 1 is not anticipated by Kiyoku.

Regarding claims 2, 13, and 17-24, Applicant relies upon his arguments regarding claim 1.

With respect to claim 10, in the same manner as with respect to Cho, Kiyoku in no fashion suggests the ±100% uniform concentration aspect of the present invention.

With respect to claims 46-55, Applicant relies upon his arguments regarding claim 10.

Withdrawal of the anticipation rejection based on Kiyoku is requested.

Allowance is requested.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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